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THE MODEL SPECIFICATION OF THE TRUCK/SHOVEL SYSTEM AT HIGHVALE MINE IN ALBERTA

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MICROMEDIA

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THE MODEL SPECIFICATION OF THE TRUCK/SHOVEL SYSTEM AT HIGHVALE MINE IN ALBERTA

by

V. Srajer*

ABSTRACT

This report describes the truck/shovel logic used at Highvale mine in Alberta. The description of routing logic and of events such as loading, dumping, fueling is followed by the logic diagrams of the events. The diagrams are shown for clarification and better understanding of the logic.

The hierarchy of the truck traffic at the three-pit operations is explained and variances in using alternative access and exist ramps into pits are discussed.

The logic described in this report is being used in the development of a dynamic-event based model by the National Research Council in Ottawa.

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MODÉLISATION DU CAHIER DES CHARGES DU SYSTÈME DE TRANSPORT CAMION-PELLE À LA MINE HIGHVALE EN ALBERTA

par

V. Srajer*

RÉSUMÉ

Le présent rapport donne une description du programme du système camion-pelle utilisé à la mine Highvale en Alberta. Des schémas de la programmation des événements font suite à une étude de la programmation de l'acheminement, du déversement et de l'approvisionnement en combustible. Les schémas sont présentés pour expliquer et permettre une meilleure compréhension du programme.

L'organisation ordonnée de la circulation des camions dans les opérations minières des trois mines est expliquée et les variances dans l'utilisation des rampes d'accès et de sortie font l'objet d'un examen.

Le programme présenté dans ce rapport est utilisé par le Conseil national des recherches à Ottawa, pour la mise au point d'un modèle basé sur les événements dynamiques.

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1. INTRODUCTION

The report on the model specification of truck/shovel system at the Highvale Mine, Alberta is next in a series of reports on development of computerized software models for surface coal mines (1,2). The description of events such as loading, dumping, maintenance, fueling is followed by the logic diagrams of haulage traffic. Other specified events, like refueling policies and the other non-productive events are also described.

2. MODEL SPECIFICATION

Highvale Mine is a "mixed loading" and "mixed trucking" operation, because shovels of various makes and capacities and trucks of different sizes are used there for loading and trucking.

The description of truck and shovel operation at the Highvale Mine was described earlier (1). The recommended logic for development of the truck and shovel model is discussed here. The logic will be the same for any shovel and any size of the bottom-dump coal hauler. The logic and assignment will be different for the Dart loader and rear-dump trucks.

In this report the events that happen during loading, dumping, maintenance, and fueling and the logic associated with truck traffic at various locations of mine area are formulated. The non-productive events are identified and incorporated in the overall logic of model specification.

2.1 LOADING

Loading of coal is an operation event carried out at various locations in Pits 02S, 03 and 04. There could be one or more simultaneous loading events in each pit.

The loading event comprises of the following truck movement at the loading site:

1. Arrive at loading site
2. Join empty trucks queue
3. Arrive at loading position
4. Commence loading

5. Complete loading
6. Depart from the loading site

The sequence of the loading events could be interrupted at anytime if some other event, such as non-productive time, is introduced. Non-productive time may be coffee time, shovel or truck breakdown, weather, foreman instructions etc. The shovel will not commence cleaning or moving when a truck arrives in loading position. Also the event of loading is completed when non-productive time - shift change - occurs.

The possibility that the half loaded truck is advised to move immediately to another shovel exists but is very unlikely. The exception is a shovel breakdown. The loading site event diagram is presented in Fig. 1.

Only the single sided loading is practised at the Highvale Mine. The trucks move into the loading position for loading with the shovel dipper moving over the trailer box, never over the driver cabin.

The loading event could also be interrupted by the shovel operator advising the truck driver to move slightly ahead for loading of the second half of the trailer box. This event is usually up to 3 seconds duration. Generally, the shovel operator holds the dipper above the trailer box and gives a signal to the truck operator when the position of dipper above the truck is satisfactory.

A similar loading site event hierarchy occurs for the loading of ash trucks at the ash loading site in the Sundance plant. Loading is continuous by using a chute. The chute operator could give a signal to the truck driver to move the truck ahead for full box loading. Because the loading is continuous, no delay in loading is experienced here.

The loading by the Dart loader is also similar, except there is no interruption of the loading event for filling front and rear end of the trailer box. The loader will load the front and rear end of the truck from different positions. This seems to be a more flexible method of loading than by the shovel. However, the shovel loading is much faster and the shovel operator has a better view of the truck load than the loader operator. Also, less clean-up around the truck is required. On the other hand, the loader could clean up the bench better than a shovel, and no auxiliary equipment like the front-end-loader is required.

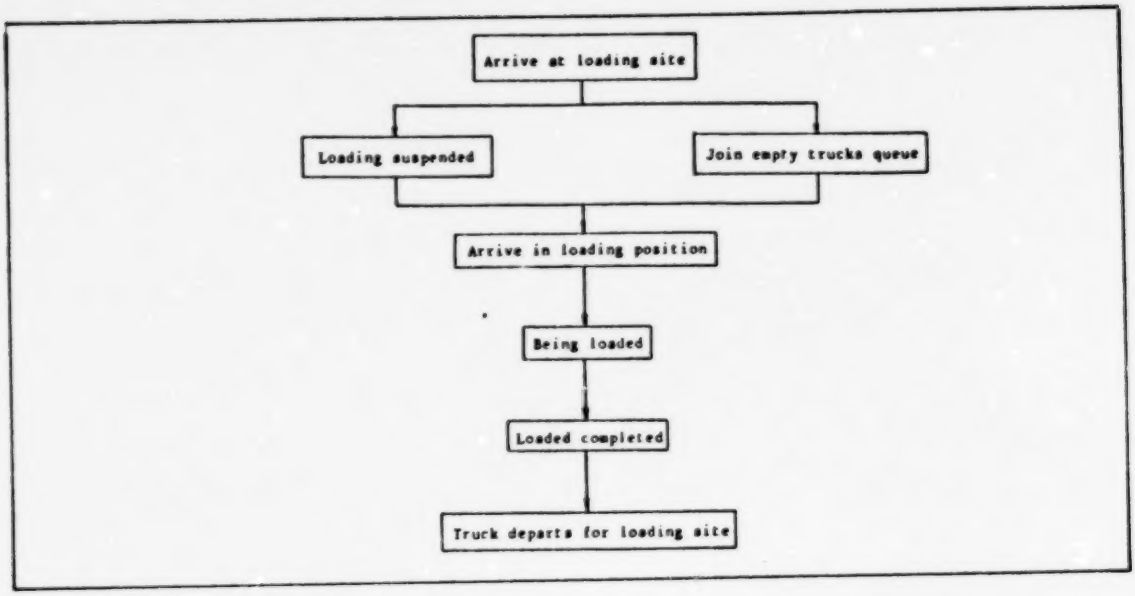

Fig. 1 - Loading site event diagram

2.2 DUMPING

The dumping of coal at the Highvale Mine occurs at the Sundance plant location, the Keephills plant and the MCL coal storage. The dumping of ash event was observed at two locations, both between spoils of the Pit 02N.

The Sundance dump area is shown at Fig. 2. The routing logic for the trucks arriving from Pit 02 and 04 is on Fig. 3, for the trucks from Pit 02 on Fig. 4, and for the trucks arriving from shop or for the loaded ash trucks at Fig. 5.

There is one way traffic flow around the Sundance hoppers. The coal haulers from Pit 03 and 04 enter the Sundance hopper traffic circle from north road at point NH1. The routing logic is on Fig. 3. The empty trucks will bypass NH5 hopper at east side and drive by NH11 and NH10 to shops for scheduled maintenance. The loaded trucks make a decision at point NH1 - to dump at NH5 or SH3 dump, based on the scheduled assignment or last minute requirement (indicated by red light at dumper "No dumping" or green light at dumper "dumping". The routing logic for NH5 dump is abbreviated by symbol (A), routing logic at SH3 dump by symbol (B) on Fig. 3.The exit from dump could be to shop area for the scheduled maintenance or for repair. The hauler could also exit at SH7 point to be relocated for loading at Pit 02S. The routing logic for pit 02S is on Fig. 4.

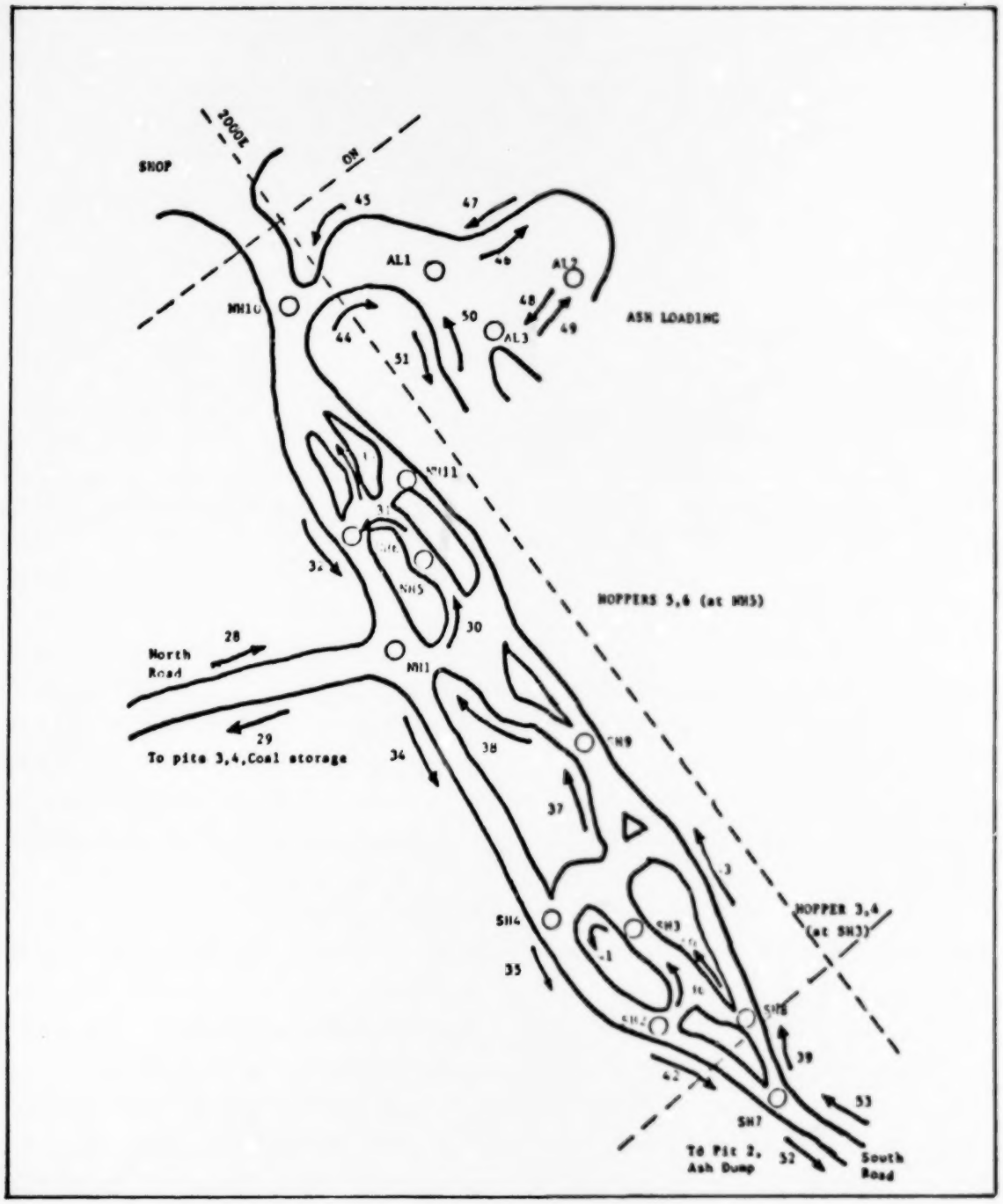

Fig. 2 - Layout at Sundance

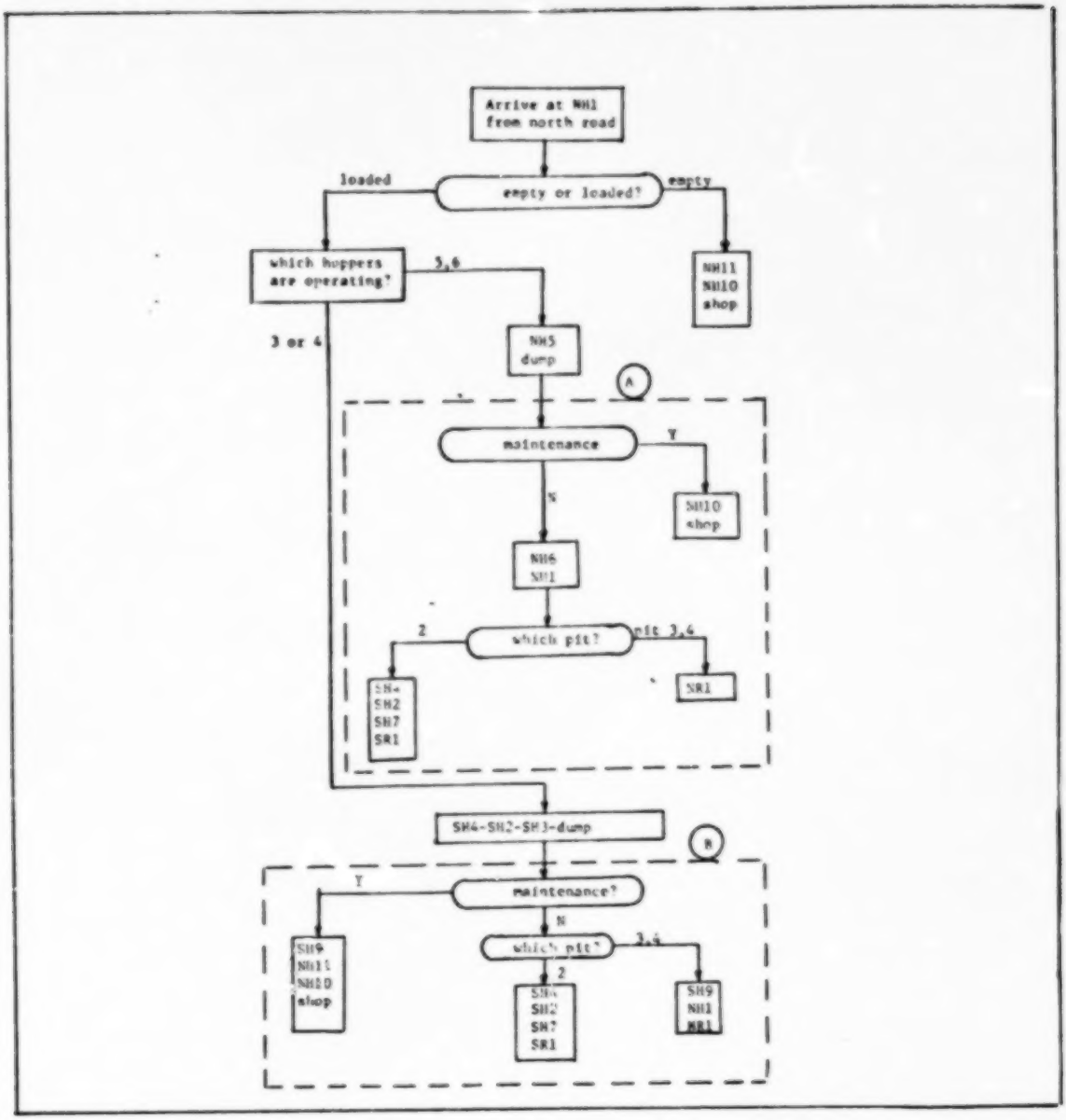

Fig. 3 - Sundance routing logic (part 1)

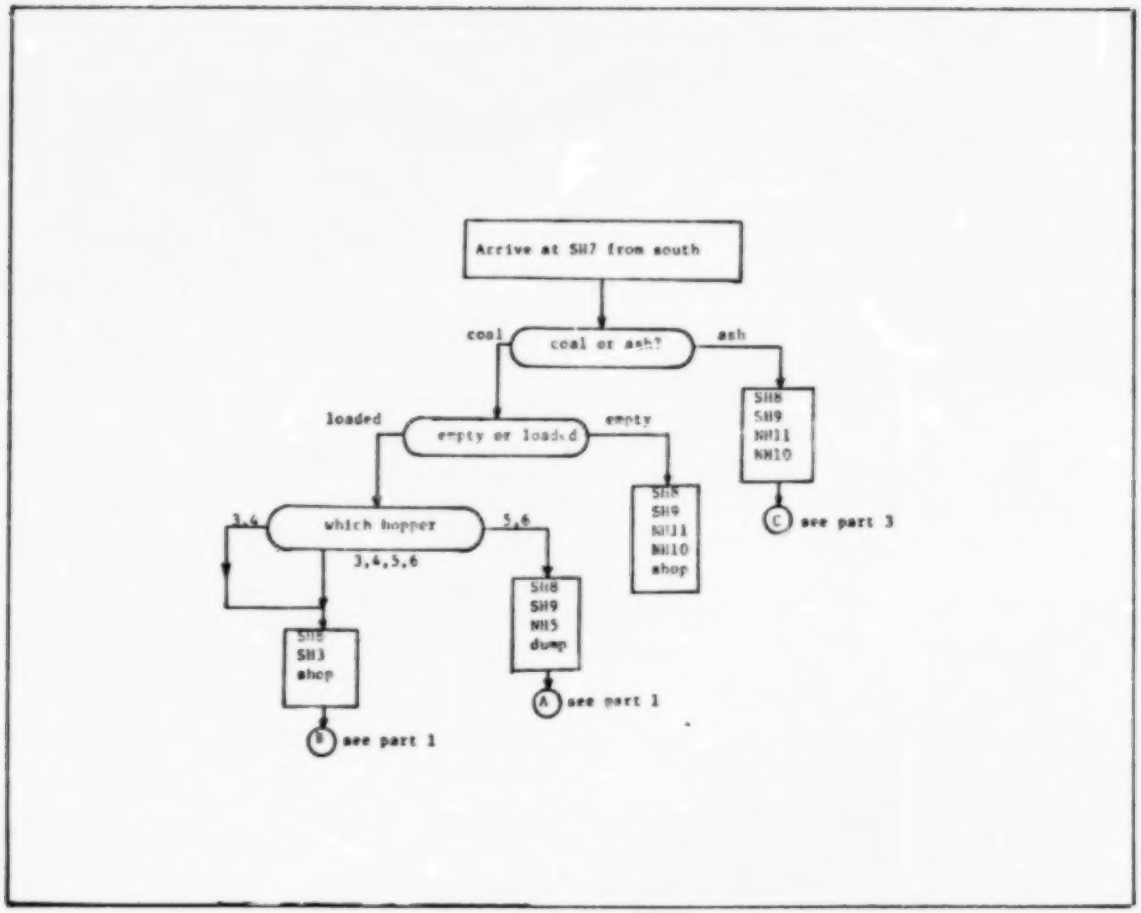

Fig. 4 - Sundance routing logic (part 2)

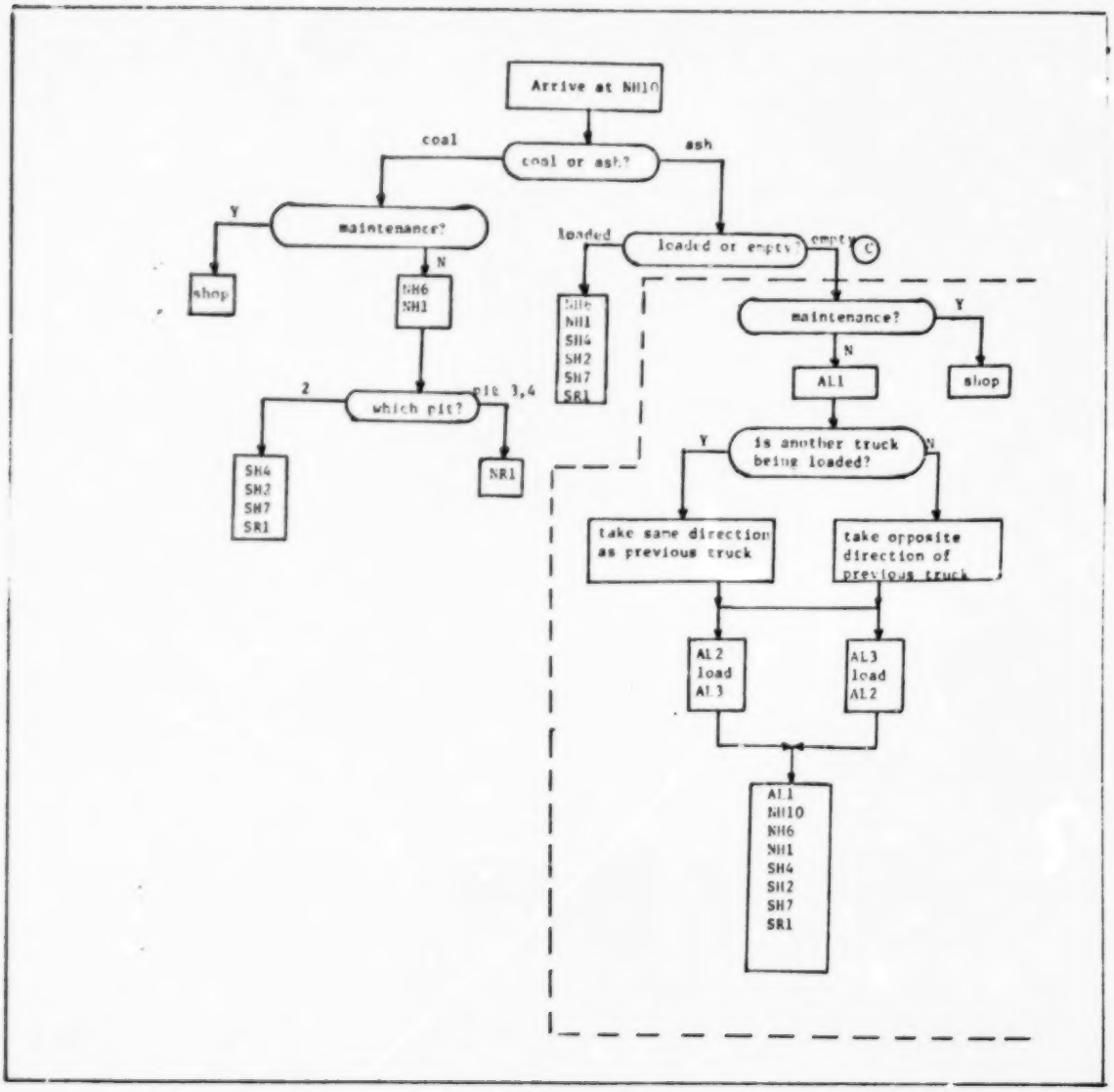

Fig. 5 - Sundance routing logic (part 3)

The coal haulers, loaded, will enter one of the hoppers they are assigned to, using same logic - (A) or (B) as described on Fig. 3. The empty haulers will drive through to the shop using a bypass at east side of the Sundance hoppers. The ash trucks entering at point SH7 empty will drive similar truck route to the point NH10 and enter the ash loading area at the point AL1. The loaded ash trucks will enter the Sundance hopper area at NH10 point and exit at SH7 using bypass route west of the Sundance hoppers.

The routing logic for trucks entering the Sundance traffic circle at NH10 is described on Fig. 5. The trucks could enter point NH10 from several directions. The routing logic is therefore described by using various assignment of the trucks. The ash trucks are being loaded at the ash loading facilities, described under symbol (C). The ash trucks could enter the ash loading facilities at point AL3 from two directions: directly from AL1 or by AL2 route. The coal trucks that pass by NH10 point are always empty because they are in transit to the shop for scheduled maintenance or they return to various pits after the scheduled maintenance is completed.

The dumping at point NH5 or SH3 comprise of the following events described at Fig. 6.

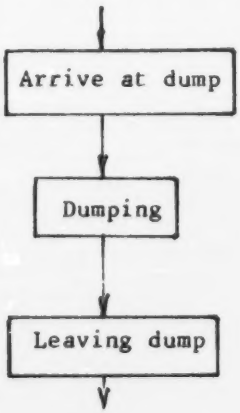

Fig. 6 - Sundance dumping site diagram

Dumping at the Keephills plant is more straight forward (Fig. 7). The coal haulers will enter the Keephills dump area at point KH1, dumping their load at point KH2 and existing at KH3, completing the cirle to point KH1. The standard practice is to enter the dump area of the Keephills hopper by trucks from Pit 02S only. The routing logic for loaded trucks at the Keephills hopper is in Fig. 8.

Coal delivery to the MCS (Manalta Coal Storage) area is shown on Fig. 9. The fully loaded trucks will enter the MCL coal storage at NR1 and start dumping anywhere between ST1 and ST2 points. The empty trucks will exit the storage area at NR2 point, continuing back to Pit 03 or 04 to be loaded or turning to NR1 and driving to the shop for repair or to Pit 02S for other assignment. The routing logic for coal deliveries to storage is on Fig. 10.

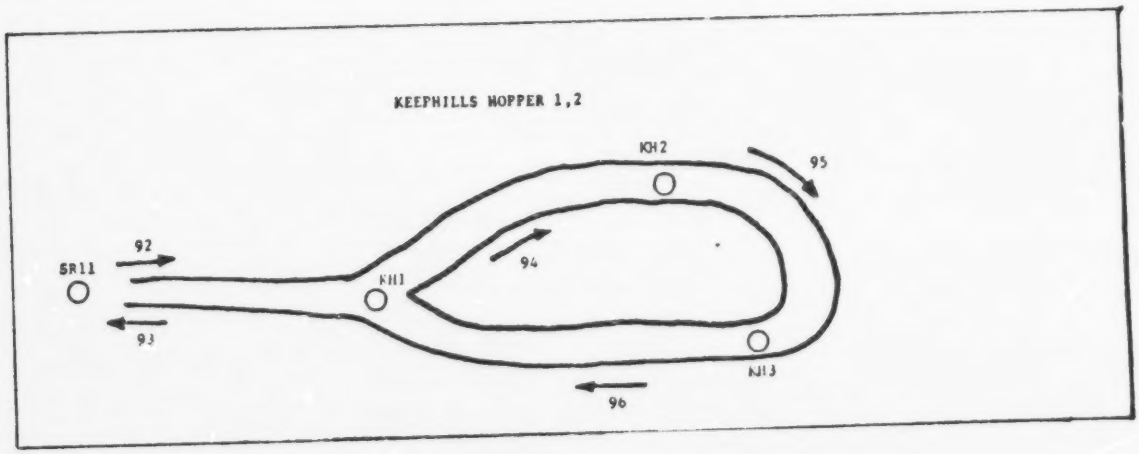

Fig. 7 - Coal delivery to Keephills - road layout

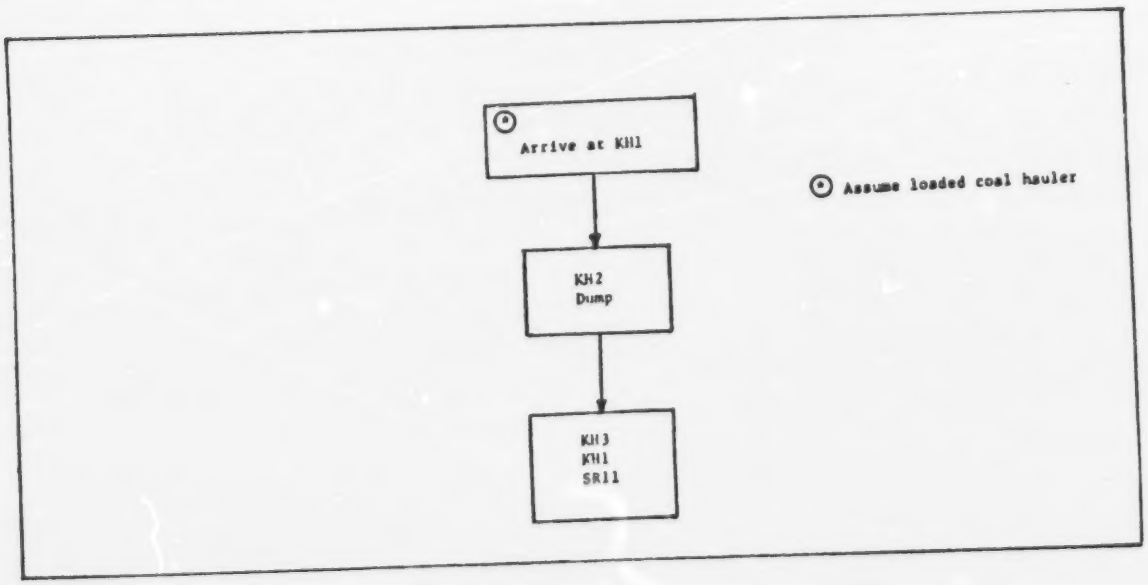

Fig. 8 - Routing logic at Keephills dump

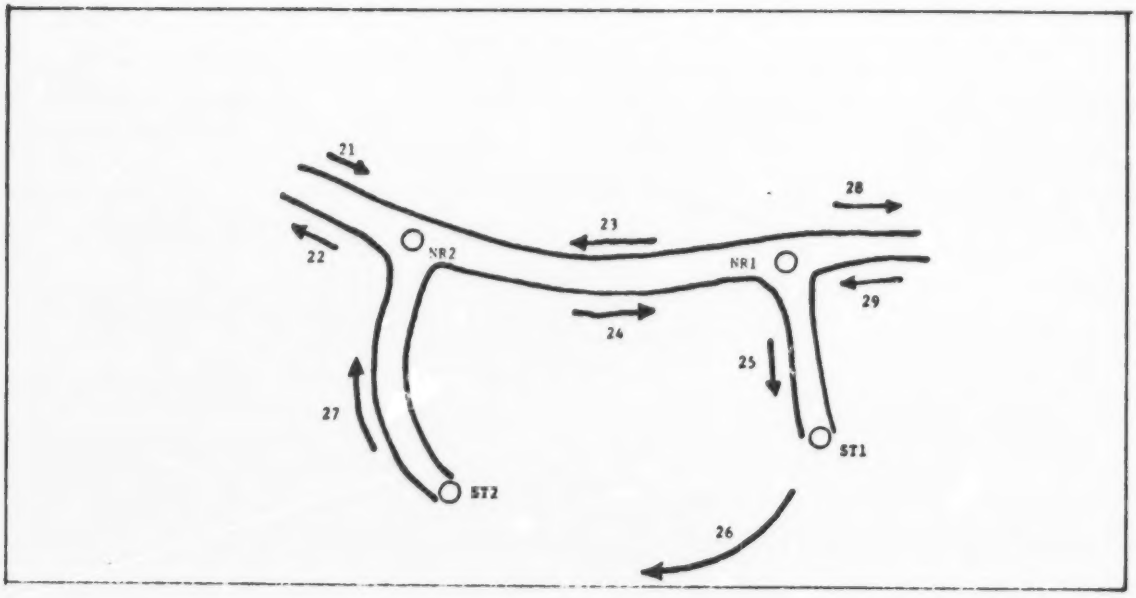

Fig. 9 - Coal delivery to coal storage - layout

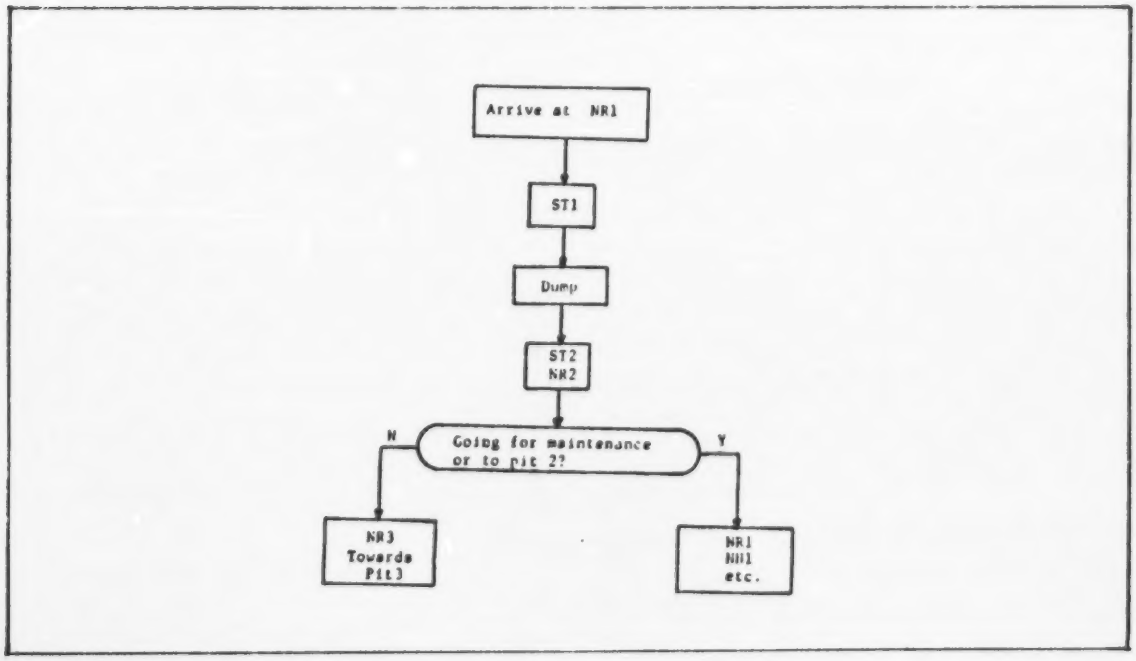

Fig. 10 - Coal delivery to coal storage - routing logic

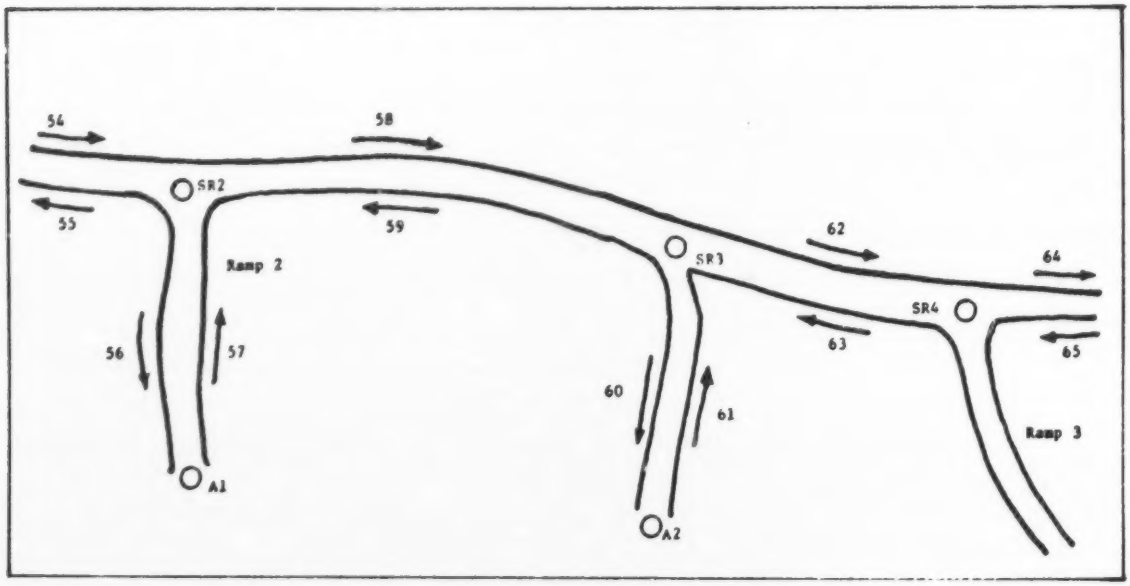

Fig. 11 - Layout at ash dump

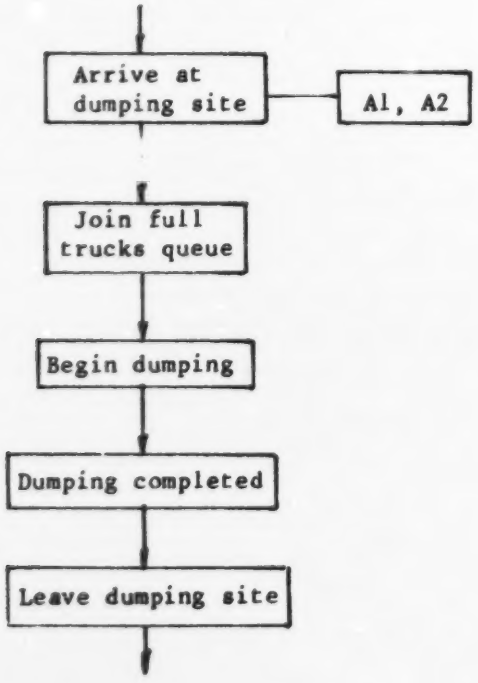

Fig. 12 - Ash dump logic diagram

The ash trucks loading logic is described in Fig. 5 as a part of the Sundance routing logic. The ash dumping observed during field studies was between spoils at Pit 02N. Two dumping sites were observed: (a) south of point SR2 is called (A1); (b) south of point SR3 is called (A2). Access to the dumping point (A1) is by ramp 2 off the mined-out Pit 02N, access to the dumping point A2 is by a temporary access road. The points A1 and A2 are of no fixed location. Trucks were observed to dump ash as close as ten metres south of points SR2 or SR3 and as far as 800 metres away. The general layout at the ash dump is shown in Fig. 11, and the dumping logic diagram is on Fig. 12.

Dumping by the "in-pit" trucks, listed under Nos. 8126, 8127 and 8225 is not described. These trucks are on various assignments in pits or are used to pack the coal storage dumps. They were not part of the study at the present time.

2.3 TRUCK TRAFFIC

Only two pits (pit 02S and 03) were sufficiently monitored to describe the layout and routing logic for coal haulers. The traffic layout for Pit 03 is in Fig. 13, layout for Pit 02S is in Fig. 14. The truck routing logic for Pit 03 is in Fig. 15, for Pit 02S in Fig. 16.

The routing logic described in this chapter is the complete routing logic for the Highvale Mine and could be used as an example for development of similar layouts and diagrams for other pits or for the same pit, but for different access and exit ramps.

The truck can enter Pit 03 layout area at point NR5 coming empty from the Sundance dump or driving loaded at point NR7 from Pit 04. The loaded truck will not enter Pit 03 routing logic area and will leave Pit 03 layout area at point NR5 on its way to the Sundance dump or the MCL storage dump. The truck entering empty at point NR5 have the choice to continue to Pit 04 or, to enter Pit 03 at ramp no. 31 if so assigned. A similar decision is made at NR6 to enter pit by ramp 32, or at NR7 to enter pit by ramp 33 or leave the pit layout area. By entering the pit using either of the above ramps, the trucks will reach the pit bottom at point 03-4 from ramp 31, point 03-1 from ramp 32, or point 03-6 from ramp 33. These points are the pit floor points. Passing these points the trucks enter the "loading logic areas" as described earlier. After the completion of loading, the trucks

exit the pit by the assigned exit ramp. Here there is another logic, where the loaded trucks are automatically assigned to ramp, within little or no congestion. Some of the congestion factors are:

- Drilling and blasting
- Removal of partings
- Other coal haulers
- Shovel located close to ramp
- Interference with dragline operation
- Pit geometry

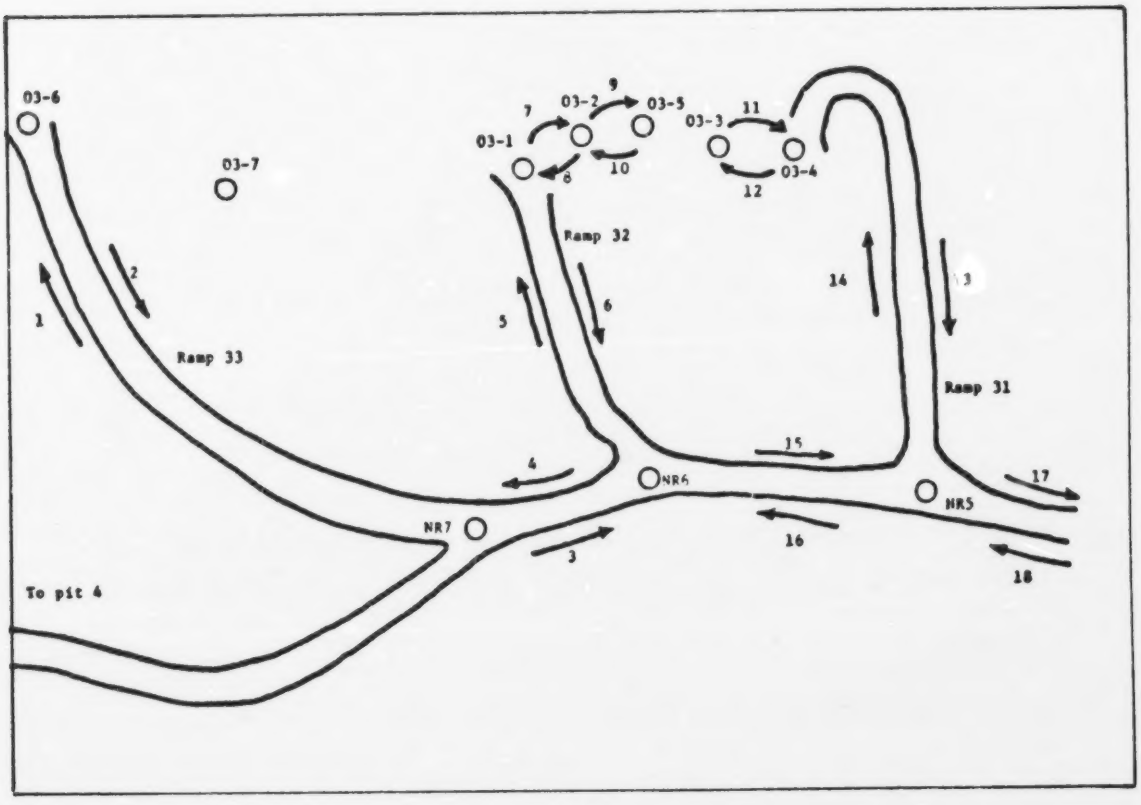

Fig. 13 - Layout for Pit 03

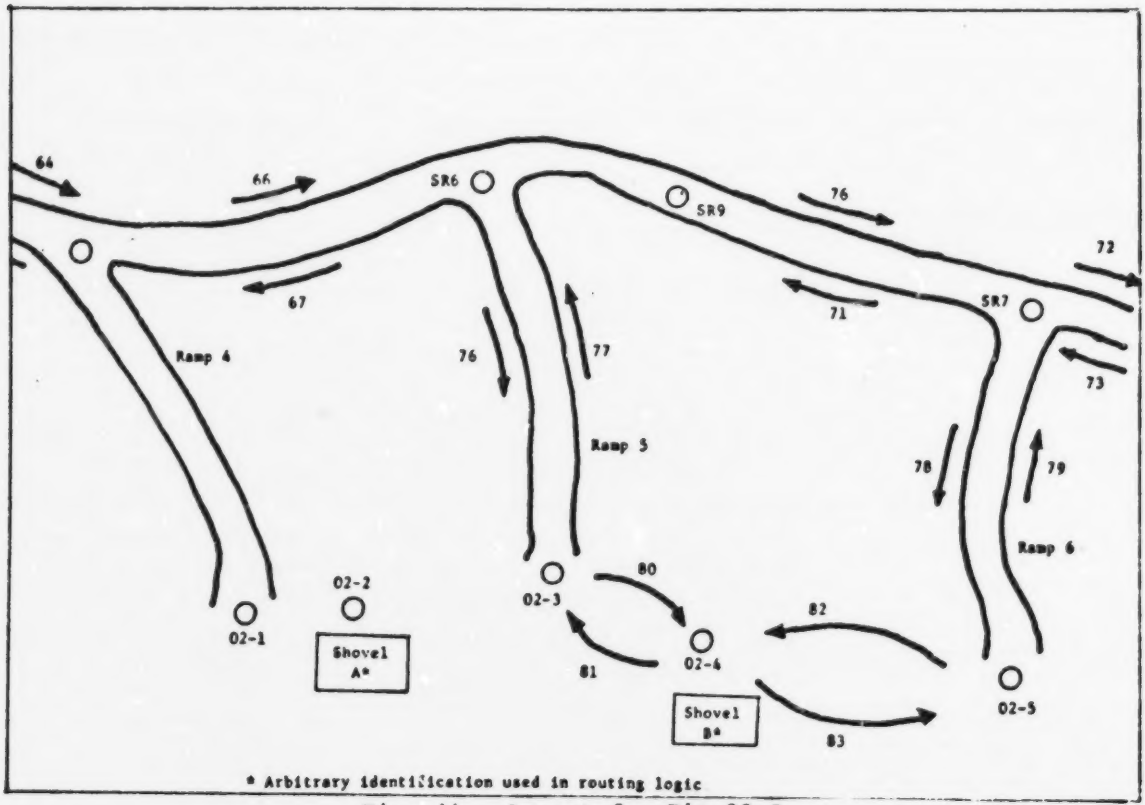

Fig. 14 - Layout for Pit 02-S

The truck will proceed to the assigned ramp only when there are no congestion factors. Otherways, the truck will drive from the pit using selected closest ramp from the point of loading. Sometimes the truck must turn around itself after being loaded. The exit from the pit is by ramps 31, 32 or 33, leaving Pit 03 layout area at NR5, and continue to the Sundance dump.

Another event observed during field studies was a change in truck assignment by a pit foremen from one pit to the other, because there was no coal to be loaded. The truck left Pit 03 unloaded at point NR7 to be reassigned to Pit 04.

The coal haulers could enter the Pit 02S layout area at point SR5 loaded from the Sundance dump or the shops, or at the point SR7 returning unloaded from the Keephills dump. The truck arriving from the Keephills dump could also pass through for maintenance and leave the Pit 02S layout area at point SR5. The routing logic is described in detail in Fig. 16. The trucks from the Sundance dump will enter Pit 02S by ramp 4, 5 and 6, depending which

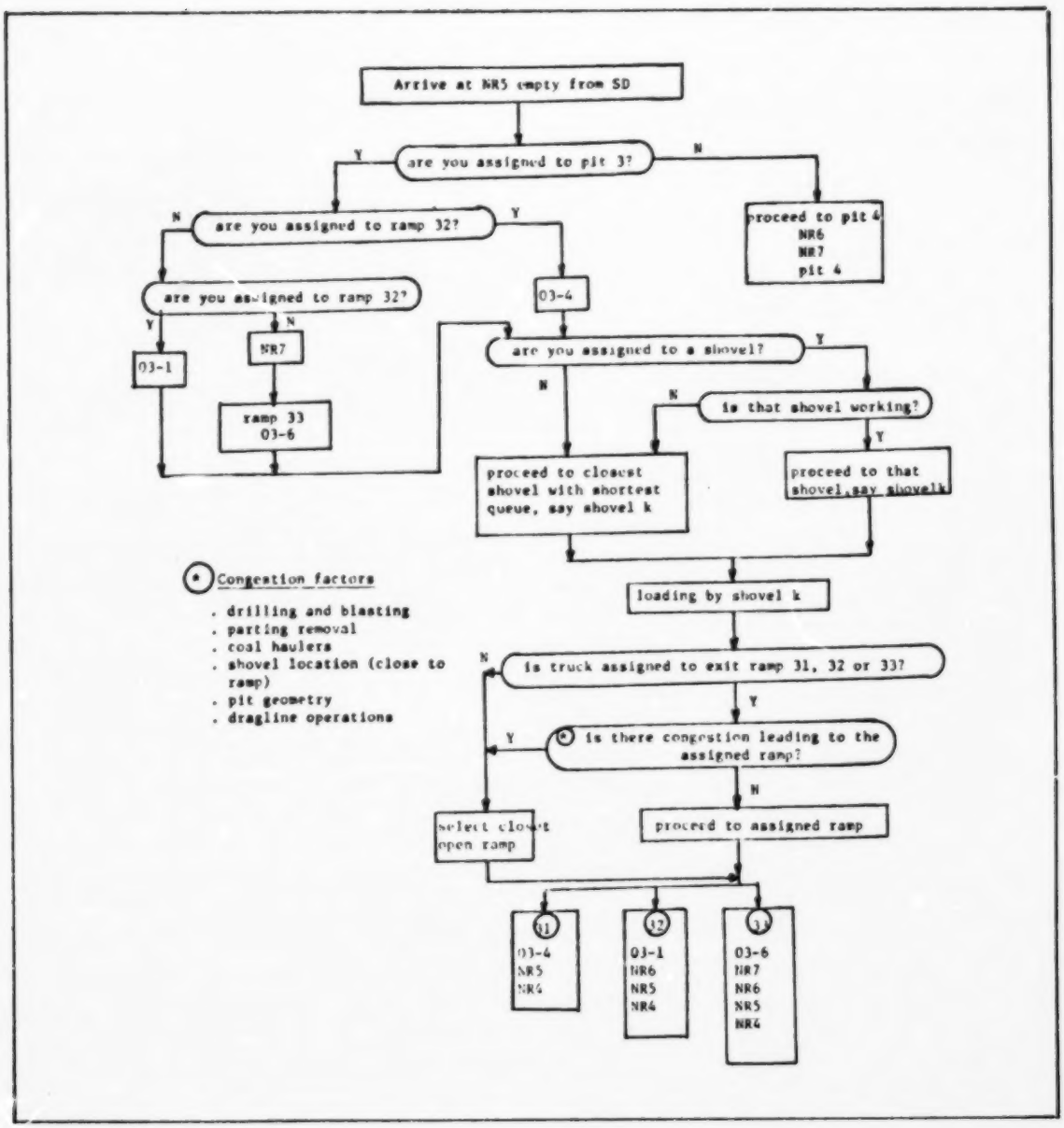

Fig. 15 - Pit 03 routing logic

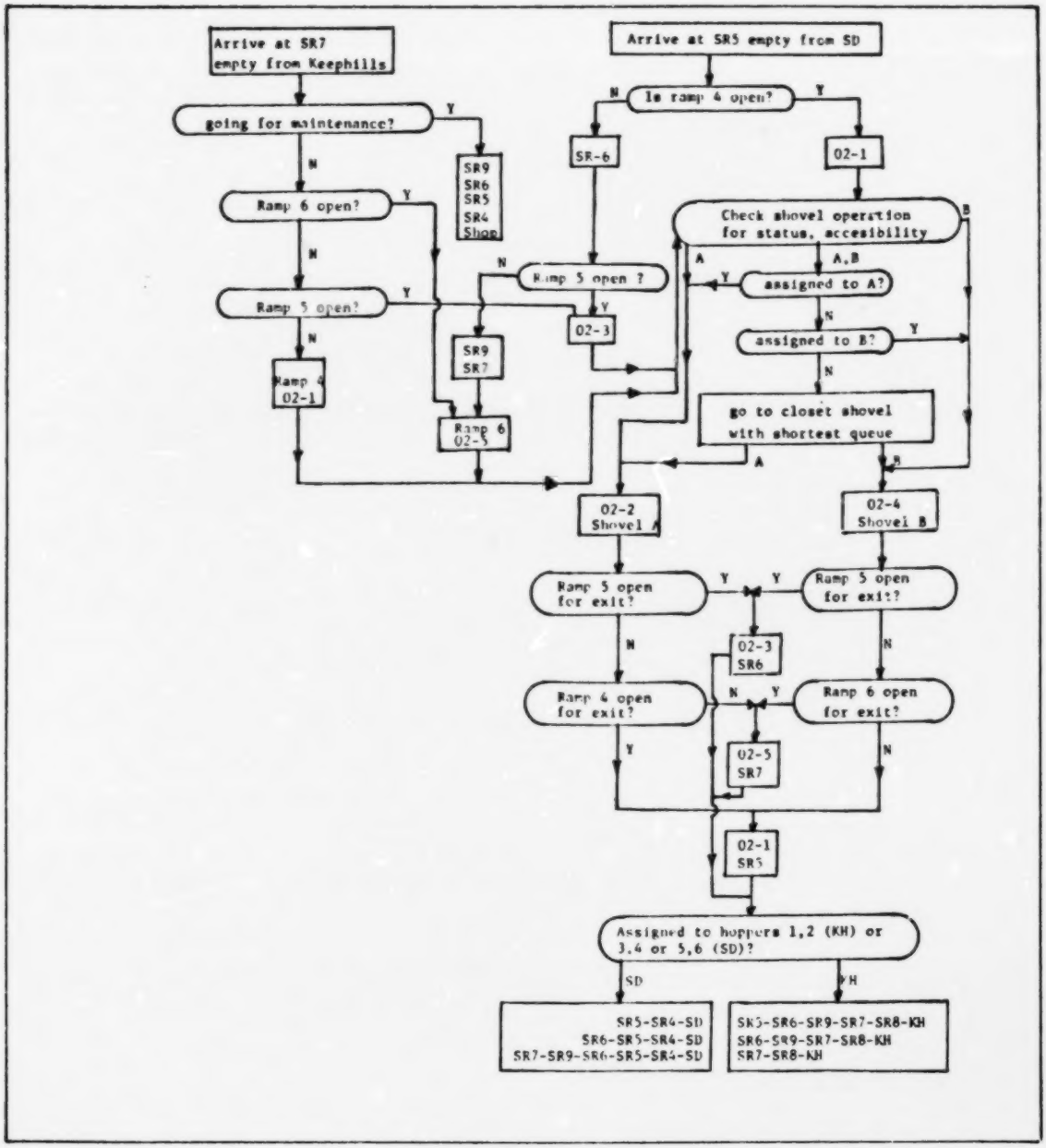

Fig. 16 - Pit 02-S ramp/loading logic

one is open or to which one the truck was assigned. The loading sequence is commenced when the truck reaches point 02-1 from ramp 4, 02-3 from ramp 5 or 02-5 from ramp 6. The truck from Keephills dump will choose the ramp access to the pit in the opposite way from a truck from the Sundance dump. By entering the ramp 6 it will commence loading sequence at point 02-5, or by using ramp 5 it will reach point 02-3 or by ramp 4 it will reach point 02-1. At the pit floor the loading logic is similar for any truck. The exit from pit and end of the loading sequence is similar for any truck assuming that only one loading shovel is used. When both shovels are used, truck assigned to the Sundance dump should logically use the closest ramp at the west side of the pit, truck assigned to the Keephills dump should use ramps at the east side of the pit. However, this is not always possible, because some ramps are closed and non-accessible and sometimes there is congestion in the pit. To derive the logic for the model, the following routing is recommended:

1. A truck entering pit will check shovel for status and accessibility.
2. If the truck has its own assignment to shovel A or shovel B it will proceed to a shovel.
3. If the truck is not assigned to any specific shovel it will go to the nearest shovel with the shortest queue.
4. Truck is loaded at shovel A or shovel B.
5. Truck at west side of the pit (shovel A) will exit by ramp 5 if it is open, otherwise by ramp 4.
6. Truck at east side of the pit (shovel B) will exit by ramp 5 if it is open, otherwise by ramp 6.
7. It is recommended to use the ramp 5 for exit only. Sometimes the operation in pit will not permit this arrangement (congestion in pit and so on). Alternative decision should be made by the operator.
8. Truck assigned to the Sundance dump will exit Pit 02S layout area by ramp 4, 5 or 6 at point SR5.
9. Truck assigned to Keephills dump will exit Pit 02S layout area by ramp 6, 5 or 4 at point SR7.
10. Truck assigned to the shop for preventive maintenance will exit the same way as truck assigned to Sundance dump. It is assumed the truck going for maintenance is also fully loaded and it will dump its load at the Sundance dump before driving to the shops.

The truck with serious mechanical problem could be sent to shops for repair (or towed away) unloaded.

2.4 MAINTENANCE

Each truck operating at the Highvale Mine is assigned a fixed maintenance check period during each shift (called TOP-UP). This assignment for maintenance is noted by the truck driver at the bulletin board in the change room before commencement of his shift. The truck must arrive for top-up at specific time. It is expected that it will arrive at the shop no later than 10 minutes after the scheduled time. It was observed that, truck drivers were able to control this time quite accurately. This daily scheduled maintenance does not last more than 30 minutes.

The truck could also develop mechanical problems in the field in which case immediate repair is necessary. The standard practice is to repair a truck in the field if the repair is apparently less than two hours. Repairs over two hours are done in the shop. The response time for the mechanical truck to arrive to the breakdown hauler is almost immediate. It was observed in Pit 03 that repair commenced in 20 minutes after mechanical truck was called in.

To account for mechanical delays, breakdown of haulers, etc., model should use average down times described in (2). The major maintenance schedule for each truck is in Table 1.

The average number of coal haulers operating is 8. Four ash haulers were observed working most of the time during field studies.

The repaired coal haulers are parked in front of shop in the "yard ready" line and marked on assignment board as "yard ready". Other trucks awaiting repair or being repaired are marked as "down". They are parked in the "down" line outside shop or are in the shop.

It is not likely that the truck will be removed from service during a shift for scheduled major maintenance (3,4). However, the event could happen and the following logic as indicated in Fig. 17 is therefore proposed as a policy to be adhered to.

Table 1 - Major maintenance schedule

Operating hrs (hrs)	Maintenance time (hrs)
250	8
500	12
750	8
1 000	12
1 250	8
1 500	12
1 750	8
2 000	5-6 days

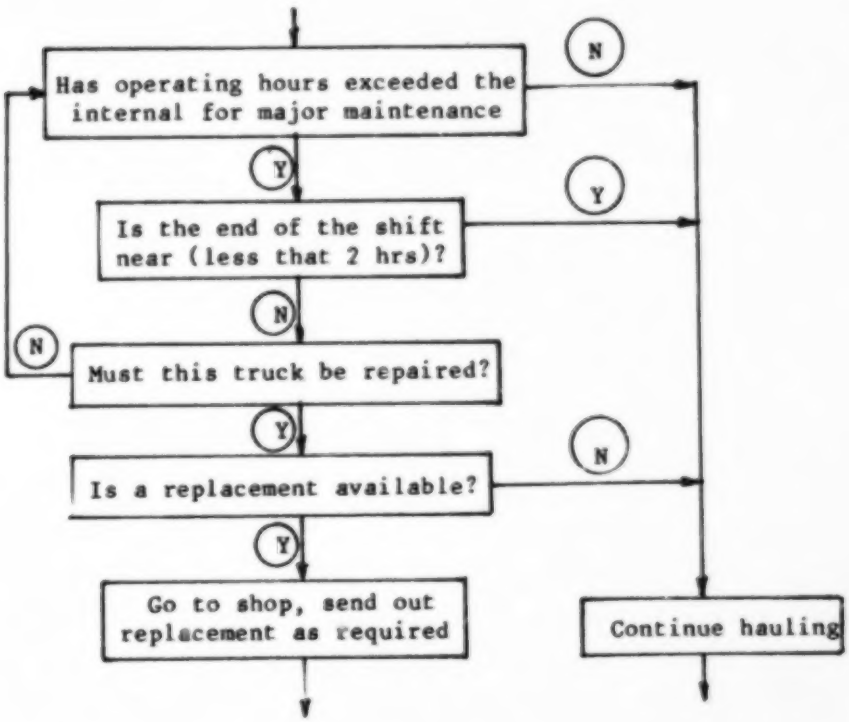

Fig. 17 - Service policy logic

The coal and ash haulers could be fueled at the permanent fueling stations south of the Sundance hopper, near point SH7 or by a fuel truck in field.

It was observed that a fuel truck was stationed at the north road near point NR3 and that it was observed entering each pit twice a shift. Each coal hauler will pass the fuel truck at least once before its move to another location. High pressure fueling is utilized, maximum fueling time for truck observed was 5 minutes. The maximum time of fuel the truck stationed in pit as observed was close to 35 minutes. The fueling will not commence during scheduled coffee breaks, but fueling is completed after commencement of coffee breaks. The truck is not fueled while being loaded.

Figure 18 indicates the logic recommended for truck refueling policy.

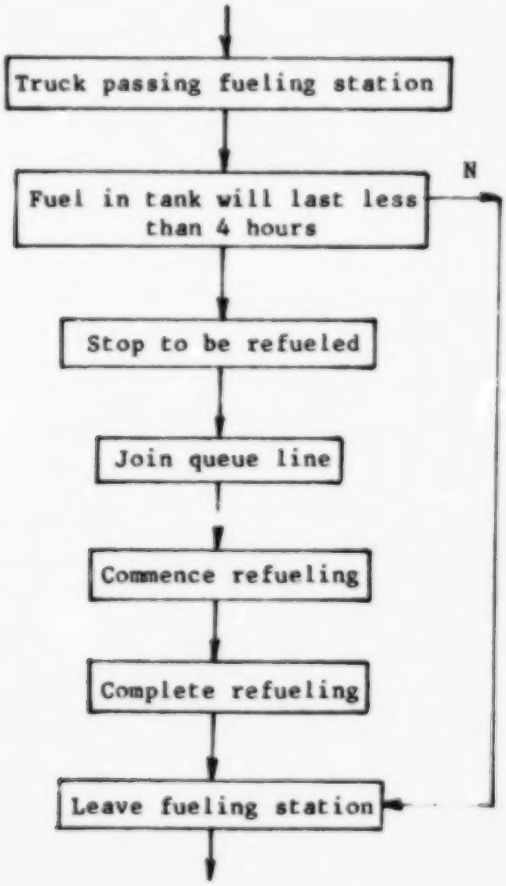

Fig. 18 - Refueling policy diagram

2.5 FUELING

A comparative study of fuel consumption per operating hour for each type of truck is in the time study report (2). The study is for the period from April 1982 to February 1984. Using the available data, the frequency of fueling and the consumption of diesel fuel could be predicted.

The trucks with more than 4 hours of fuel capacity will probably stop at refueling station (or at the fuel truck) later on or during the next time fueling truck is around in pit. The fuel truck will appear at the same location twice per shift (12 hrs. shifts are at the Highvale Mine).

The logic for fuel truck at the fueling station is indicated in Fig. 19.

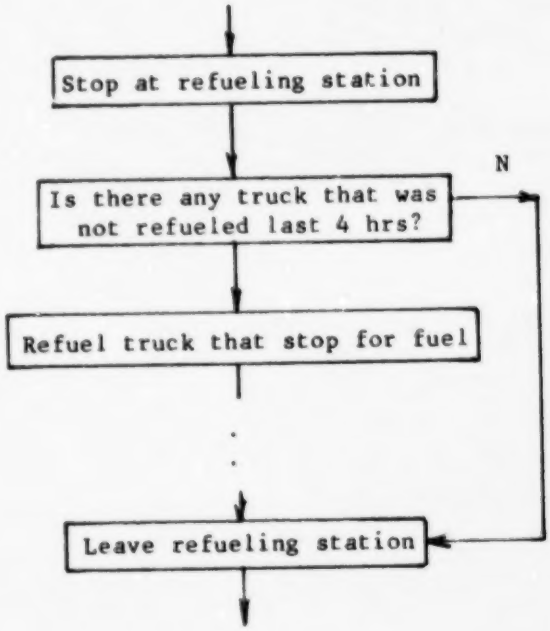
Stop at refueling station
Is there any truck that was not refueled last 4 hrs?
N
Refuel truck that stop for fuel
Leave refueling station

Fig. 19 - Fuel truck location policy

After the completion of each cycle, the fuel truck will move to a different location in the mine area.

The fuel truck will also enter the pit area and will stop to refuel any equipment on demand. If there is no demand, the fuel truck will continue driving and leave the pit area.

2.6 OTHER NON-PRODUCTIVE EVENTS

There are several other non-productive events to be taken into consideration. They are described below:

1. Power outages

If and when the shovel stops the truck is not loaded. This could be overcome by using other loader if available at the site or by reassigning trucks to other location having alternate power supply. The reassigning will be done if power outages are expected to last longer than travel time of trucks to the alternate location.

2. Beginning and end of shift

The workers are transported to the pit by bus. The arrival time was between 6:50-7:02, the departure between 18:35-18:47 for day shift and 18:52-19:04 and 6:33-6:44 for night shift respectively. On average, 21 minutes was lost due to the shift change at the day shift, 22 minutes at the night shift.

3. Coffee breaks

The coffee and lunch breaks for the coal hauling operation is as follows:

Day shift	Night shift
09:00 - 09:10	21:00 - 21:10
11:00 - 11:10	23:00 - 23:10
13:00 - 13:10	01:00 - 01:10
15:00 - 15:10	03:00 - 03:10
17:00 - 17:10	05:00 - 05:10

Total of 50 minutes is allocated for the coffee breaks for each 12 hours shift.

It was observed during field study, the coffee breaks are observed almost exactly as scheduled. The average time spent on coffee breaks in Pit 02S and Pit 03 during field study was even less than scheduled (9:37 minutes average).

4. Traffic delays

Trucks entering the pit empty will yield to the loaded trucks, if both vehicles are using the same ramp. It was observed at ramp 31, Pit 03, that delay could be as much as four minutes. Another delay occurs when the coal haulers waited for the water truck spraying pit floor. During warm weather in June 1983, the water truck drives through Pit 02S four times. Twice there was interference with the loading operation, once the water truck waited for the coal hauler to pass-by. It is safe to state however, that the delay because of water spraying is less than one minute per 12 hour shift.

5. Blasting

No delay because of blasting was observed during field work. It is estimated that delay because of blasting will be less than one minute per 12 hour shift and therefore is considered negligible.

6. Weather

Heavy rain, snowfall, fog, high wind will cause delay or stoppage of the mining activities. The work delay, such as heavy rains at the end of June and in July, could stop the production for several hours. During the field study, production stopped only once for half an hour because of heavy rain.

Several tables were developed to relate tire penetration to road bed code and season code (5,6,7). All tables are quite arbitrary and could not be used for the Highvale Mine. The tables also generalize four seasons, each with one code only. This is not applicable to the case at the Highvale Mine. It is recommended to use road bed code with relation to precipitation and time of the year. Table 2 should be used for the time being before a more accurate standard is validated in field.

The values in Table 2 are the estimates of tire penetration (in cm). The loading areas in the pit should be considered equivalent to the roadbed codes 2, 3 or 4, depending on location and material in pit. Driving over coalbed (unblasted) is equivalent to a well packed gravel (code 1).

Table 2 - Season/roadbed codes

Month/ season code		Roadbed code				
		1=gravel	2=clay	3=sand	4=mud	5=snow
Jan	1	2.5	2.5	2.5	2.5	2.5
Feb	2	2.5	2.5	2.5	2.5	2.5
Mar	3	2.5	2.5	2.5	2.5	5.0
Apr	4	3.0	4.0	5.0	7.5	-
May	5	5.0	6.0	7.5	10.0	-
Jun	6	7.5	10.0	12.5	15.0	-
Jul	7	15.0	17.5	20.0	30.0	-
Aug	8	7.5	10.0	12.5	15.0	-
Sep	9	7.5	10.0	12.5	15.0	-
Oct	10	2.5	2.5	2.5	5.0	-
Nov	11	2.5	2.5	2.5	2.5	2.5
Dec	12	2.5	2.5	2.5	2.5	2.5

7. Personal delay

Other non-productive event, such as safety and union meetings, operator no-show or tardiness, work not available but scheduled, etc., should be considered as personal delays. Such delays are unpredictable, uncontrolled and impossible to be scheduled and included in the computer model. It is recommended that values of personal delays should be incorporated in model on "as happen" basis with the straight time value loss (8).

3. CONCLUSION

The routing logic of the surface mine trucking operation as described here will be used in the development of the truck/shovel computer model by the National Research Council. The purpose of this report is to summarize hierarchy of events at the mine site, prescribe the model logic during loading, dumping, traffic, maintenance, fueling and other non-productive events.

In this report, each event associated with the truck/shovel operation is divided into various partial events, such as truck movement at the loading site, on the dumping site, etc. Each event is shown by its own event diagram for clarification and better understanding of the logic. The logic is described for all trucks operating at the mine site. This includes

the coal haulers as well as the ash haulers. The hierarchy of the truck traffic at the three-pit operation is explained in the layouts and diagrams for each pit. The variances in using different access and exit ramps are discussed, as well as congestion factors in pits, around loading and dumping points. The truck assignments, the loading and dumping sequences to optimize mine production are also described. The maintenance and fueling policies are presented in the service and refueling policy diagrams. The other non-productive events such as power outages, shift changes, coffee breaks, traffic delay, blasting, weather and road condition are evaluated. The season/roadbed code to include various conditions of the haulage road at different times of the year is presented and recommended to be used to correlate the tire penetration and the roadbed and season code.

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